Estimating Rates of Motor Vehicle Crashes Using Medical Encounter Data: A Feasibility Study

Cynthia J. Thomsen, PhD
Jordan A. Levine, MPH
Isabel V. Altarejos, MPH
Robyn M. Highfill-McRoy, MA, MPH
Jennifer McAnany, PhD
Travis N. Ray, BA

Naval Health Research Center

Report No. 16-01 supported by Office or the Deputy Assistant Secretary of the Navy for Safety, under Work Unit No. N1427. The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of the Army, Department of the Air Force, Department of Veterans Affairs, Department of Defense, or the U.S. Government. Approved for public release; distribution unlimited.

Human subjects participated in this study after giving their free and informed consent. This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research (Protocol NHRC.2014.0038).

Naval Health Research Center
140 Sylvester Road
San Diego, California 92106-3521

Executive Summary

Purpose: The present feasibility study was undertaken to determine whether medical encounter data can be used to estimate rates of nonfatal motor vehicle crashes (MVCs) among U.S. Navy and Marine Corps personnel. The study also aimed to describe characteristics of medical encounters for MVC-related injuries and investigate differences in MVC rates over time and as a function of branch of service, sex, rank, deployment history, and location.

Methods: A comprehensive database for the 5-year period from 2009 to 2013 was constructed by merging three separate databases containing (1) accession and demographic data for all U.S. Navy and Marine Corps personnel on active duty, (2) data regarding all inpatient and outpatient medical encounters of Department of Navy (DoN) personnel during this period, and (3) data for all DoN deployments in support of the Global War on Terror. Classification of medical encounters resulting from an MVC was based on ICD-9 External Causes of Injury codes in medical records. An average of 521,809 DoN personnel were included in each year of the study period, and there was an average of 6,139 MVCs per year, for a total of 30,696 MVCs across the 5-year study period.

Results: Several interesting patterns were observed with respect to MVC-related medical encounters:

- The overall rate of nonfatal MVCs between 2009 and 2013 was 1.2% in both the Navy and the Marine Corps. This indicates that each year an average of 1.2 of every 100 DoN service members were involved in an MVC that resulted in a medical visit.
- There is evidence that Marines may have suffered more-severe MVCs and resulting injuries than did Sailors. Marines were more likely than Sailors to receive inpatient care for MVC-related injuries, although the use of inpatient care by Marines decreased over the study period. In addition, Marines were more likely to incur multiple and more-severe injuries (including dislocations, crushing, intracranial, and nerve/spinal cord injuries) compared with Sailors.
- Estimated MVC rates were higher for women (1.9%) than for men (1.1%). This may reflect sex differences in propensity to be injured in MVCs (e.g., due to differences in body size) and/or sex differences in medical care use, both of which have been documented in previous research. However, the present study also found evidence that men were more likely to use inpatient services, and they suffered a greater number of injuries. These findings may support the idea that women's higher MVC rates are due to their greater tendency to seek medical care, even when their injuries are less severe.
- Junior enlisted personnel (E1–E3) had considerably higher rates of MVCs (2.4%) than did other enlisted personnel (E4–E5: 0.7%, E6–E9: 0.6%) or officers (0.5%). In addition, certain indicators of injury severity, including greater use of inpatient care and

higher number of injuries, suggest that junior enlisted personnel were more likely than those in higher ranks to be involved in severe crashes. Motor vehicle crash rates among junior enlisted personnel were higher in the Navy than in the Marine Corps (2.7% vs. 2.0%). Moreover, rates of MVCs increased over the 5-year study period for junior enlisted personnel in the Navy, but not for their counterparts in the Marine Corps.

- Past-year deployment in support of the Global War on Terror was associated with increased MVC rates (1.3% for those who had returned from deployment in the past year vs. 0.6% for those who had not). The impact of deployment on MVC rates was somewhat larger for Marines (1.4% vs. 0.5%) than for Sailors (1.2% vs. 0.6%).
- Comparison of MVC rates in three geographic areas with high concentrations of DoN personnel revealed that rates were highest in San Diego, California (1.2%), followed by Norfolk, Virginia (1.0%), and Jacksonville, North Carolina (0.9%).
- Overall rates of MVCs declined across the 5-year study period. This decline was more pronounced in the Marine Corps than in the Navy and among female than male Marines.

Conclusions and Recommendations: The present study demonstrates the feasibility of using medical encounter data to estimate MVC rates. Although this approach is not without its limitations, previous evidence suggests that MVC-related injuries are more completely represented in medical data than in current safety recording systems. However, this issue has not been fully examined. It is likely that the most accurate estimates of MVC-related injuries could be obtained by developing an algorithm that draws from both sources of data.

Further research could address the development of such an algorithm for estimating MVC rates, and evaluate its accuracy relative to estimation methods relying on a single data source. This work could also extend the scope of this small-scale feasibility study across a longer time frame and examine a range of other individual and environmental factors that may be predictive of MVC rates. Finally, future research could specifically examine predictors of particular types of crashes (e.g., automobile vs. motorcycle).

The present results have implications with regard to interventions to reduce MVC rates. In particular, they suggest that junior enlisted personnel (in the Navy, more notably) and those who recently returned from deployment (in the Marine Corps, more notably) are at especially high risk of MVCs. These groups, therefore, should be targeted with interventions designed to reduce MVCs.

Differences in MVC rates across branch of service, geographic location, and time cannot be explained without a systematic analysis of differences in policy, procedure, and circumstance across each of these dimensions. Such an analysis could help to identify additional factors that exacerbate or mitigate MVC risk. In turn, this analysis could suggest further steps to reduce MVCs.

Within the Department of Defense, MVCs are a leading cause of medical encounters and lost work days. Reducing MVCs, therefore, has the potential to dramatically improve the health and readiness of the Armed Forces. By evaluating the causes of service members' MVCs, empirical research can provide a foundation for more effective prevention efforts. Given the devastating effects of mishaps on individual military members, as well as the immense financial and readiness costs of accidental injuries to the Navy and Marine Corps, greater empirical attention to this issue is long overdue.

Table of Contents

Section	Page
Executive Summary	ii
Tables List	vi
Figures List	vii
Introduction	1
Accidental Injuries in the Armed Forces	1
Injury Surveillance in the DoD and the DoN	1
The Present Report	3
Methods	4
Data Sources	4
Analyses	6
Results	7
Characteristics of MVC-Related Medical Encounters	7
Estimated Rates of MVC-Related Medical Encounters	10
Discussion	20
Summary of Findings	20
Implications and Recommendations	21
Strengths and Limitations	22
Future Research Directions	24
Conclusions	25
References	26
Appendix	28

Tables List

No.	Title	Page
1	Percentage of Accident-Related Injuries in Medical Data That Appeared in Safety Surveillance Data	3
2	Type of Injury by Service	10
3	Average Yearly MVCs and Active Duty Strength by Service	11
4	Average Yearly MVCs and Active Duty Strength by Sex and Service	12
5a	Type of Injury by Sex, Marine Corps	13
5b	Type of Injury by Sex, Navy	14
6a	Type of Injury by Rank, Marine Corps	16
6b	Type of Injury by Rank, Navy	16
7	Average Yearly MVCs and Active Duty Strength by Location	17
8	Average Yearly MVCs and Active Duty Strength by Location and Service	18

Figures List

No.	Title	Page
1	Percentage of Initial Medical Encounters for MVC-Related Injuries by Day of Week	7
2	Percentage of Initial Medical Encounters for MVC-Related Injuries by Day of Week and Service	7
3	Percentage of Initial Inpatient Medical Encounters for MVC-Related Injuries by Year	8
4a	Percentage of Initial Inpatient Medical Encounters for MVC-Related Injuries by Day of Week and Service	8
4b	Percentage of Initial Outpatient Medical Encounters for MVC-Related Injuries by Day of Week and Service	9
5	Number of MVC-Related Injuries by Service	9
6	MVC Rates by Branch of Service	11
7	MVC Rates by Sex and Branch of Service	12
8	Number of MVC-Related Injuries by Service and Sex	13
9a	MVC Rates by Rank, Navy	14
9b	MVC Rates by Rank, Marine Corps	15
10	Number of MVC-Related Injuries by Service and Rank	15
11	MVC Rates by Service and Past-Year Deployment	17
12	MVC Rates in Three Locations	18
13a	MVC Rates in Three Locations, Navy	19
13b	MVC Rates in Three Locations, Marine Corps	19
14a	MVC Rates in Each Location by Service, San Diego, CA	19
14b	MVC Rates in Each Location by Service, Jacksonville, NC	19
14c	MVC Rates in Each Location by Service, Norfolk, VA	19

Estimating Rates of Motor Vehicle Crashes Using Medical Encounter Data: A Feasibility Study

Accidental Injuries in the Armed Forces

Accidental injuries are "one of the biggest health threats confronting the U.S. Armed Forces."[1] Between 1980 and 2010, more than 25,000 service members died from accident-related injuries, which accounted for more than half of all service member deaths.[2,3] Efforts by both the Department of Defense (DoD) and individual services to reduce accidental deaths have yielded positive results, with rates of accidental death showing significant decrements between 1980 and 2010. Nevertheless, accidents remain the leading cause of nonbattle fatalities.[4]

Although accidental fatalities are an important military concern, they are only the tip of the iceberg. Nonfatal accidental injuries are much more common. Among service members, nonfatal injuries are the leading cause of health care encounters and lost work days.[5,6] In 2010, more than 600,000 service members received medical care for injuries,[7] and in 2004, the top 10 most common acute and chronic injuries alone accounted for approximately 25 million days of limited duty in the DoD.[8] It has been estimated that preventable accidents cost the military $12 billion to $20 billion per year in direct and indirect costs.[9] In sum, injuries place a significant burden on the Military Health System (MHS) and adversely impact military productivity and readiness.

Although accidental injuries and unintentional deaths of military personnel arise from a variety of sources, motor vehicle crashes (MVCs) are of particular concern, given that MVCs consistently account for the majority of both accidental deaths and nonfatal injuries among service members.[4,7,10–12]

Injury Surveillance in the Department of Defense and the Department of the Navy

To preserve and improve the health and readiness of the force, the DoD and the individual services have an inherent interest in maintaining accurate surveillance of accidental injuries, particularly those resulting from MVCs. Knowledge of rates and characteristics of MVC-related injuries is critical to understanding the scope of the problem and in deciding how to allocate limited prevention resources to reduce rates of MVCs. This type of information is also essential in developing, implementing, and evaluating programs, regulations, trainings, or other interventions to reduce the incidence of MVCs.

In acknowledgment of the importance of mishap surveillance, a number of DoD Instructions (DoDI 6055.07 and DoDI 6055.1) and Directives (DoDD 5134.01 and DoDD 4715.1E) have specified DoD requirements and procedures for mishap notification, investigation, reporting, and record keeping. In turn, each branch of service has developed its own instructions and directives for mishap surveillance. The Department of the Navy (DoN), for example, has issued guidance regarding mishap and safety investigation reporting and record keeping (OPNAVINST 5102.1D/CNO N09F/MCO P5102.1B).

One key issue is the determination of which mishaps need to be reported. DoN guidance defines a number of specific types of reportable mishaps. In general, a mishap involving a service member is reportable if a work-related injury or illness:

- requires medical treatment beyond first aid, causes time away from work, or results in light, limited, or restricted duty or job transfer
- involves death or permanent, partial, or total disability
- causes three or more individuals to receive inpatient care for more than observation
- results in $50K or more of material property damage, or involves a government vehicle and results in injury or $5K of property damage.

Each service has developed its own surveillance system for tracking mishaps.[9] DoN personnel use the online Web-Enabled Safety System (WESS) to report and retrieve information about mishaps. WESS allows users to enter information about mishaps, route them for validation, and electronically submit them to the Navy Safety Center. WESS includes all work-related illnesses and injuries that occurred ashore or afloat, including mishaps involving motor vehicles, homes, recreational activities, diving, parachuting, combat zones, aviation, and explosions. DoN mishap data may also be entered into the Enterprise Safety Application Management System (ESAMS). ESAMS is a more comprehensive tool designed to collect information about occupational safety and health; traffic, fire, and emergency service operations; emergency management; anti-terrorism; and force protection. By design, all mishap reports entered into ESAMS should be automatically transferred into WESS.

Scarce data are available to address the degree to which the safety surveillance data collected by each service are complete and accurate. However, some information on this issue has been provided by the DoD Military Injury Prevention Priorities (DMIPP) Working Group.[9] The DMIPP Working Group was formed on September 1, 2005, by the Assistant Secretary of Defense for Health Affairs to outline a systematic, coordinated DoD approach to injury prevention. As part of this effort, the Working Group attempted to match medical and safety records for the top five types of injuries they identified (fractures/sprains at specific bodily sites) for the year 2004. Across the Army, Navy, and Air Force, only 24% the accidental injuries appearing in inpatient medical records were represented in safety surveillance records. For outpatient data, the situation was dramatically worse: only 2% of accidental injuries in the medical records were represented in the safety surveillance data.

Table 1 provides the percentage of accidental injuries in medical records that also appeared in the safety surveillance records, separately for inpatient and outpatient cases and for each of the three services studied. As can be seen in the table, rates of inclusion of medically documented DoN accident-related injuries in WESS were 22.7% for inpatient visits and 1.5% for outpatient visits. Using medical data as the gold standard, the completeness of DoN mishap data was intermediate, between that of the Army (lowest) and the Air Force (highest).

Table 1. Percentage of Accident-Related Injuries in Medical Data That Appeared in Safety Surveillance Data

	Inpatient		Outpatient	
Branch	%	*n*/*N*	%	*n*/*N*
Army	**14.5**	184/1,270	**0.6**	387/60,945
Navy	**22.7**	132/580	**1.5**	698/45,553
Air Force	**52.7**	223/423	**4.2**	1,931/46,070

Note. Reproduced from DoD Inspector General report.[10]

As a whole, these findings suggest that safety data currently include only a minority of accidents that result in injury. Even among relatively serious accidents (i.e., those requiring inpatient care), fewer than one in four appeared in the safety data. For less severe outpatient accidents, these results suggest that fewer than 1 in 50 is represented in the safety data. The implication is that current estimates of mishap rates generated based on Service Safety databases vastly underestimate the true numbers of reportable mishaps in the DoD. These findings also suggest that military medical data may be a more reliable source of information regarding accident-related injuries.

The Present Report

The present report was commissioned by the Office of the Deputy Assistant Secretary of the Navy for Safety to investigate the feasibility of using military medical data to calculate rates of MVC-related injuries within the DoN. Previously, medical records have been used to estimate rates of accident-related injuries more generally,[9] but not with specific reference to MVCs. For the present report, rates of accidental injuries due to MVCs were estimated using medical encounter data across a 5-year study period (2009–2013). The report provides preliminary information about the feasibility of estimating MVC rates using medical data, and provides estimated MVC rates that can be compared with either DoN rates generated based on safety surveillance data or with civilian rates.

Beyond using medical data to estimate overall rates of MVCs in the DoN over the 5-year study period, the present project had two additional goals: (a) describe medical visits for MVC-related injuries in terms of the type of initial medical visit (inpatient or outpatient), the day of the week on which the visit occurred, and the type and number of injuries sustained; and (b) examine differences in MVC rates as a function of several other factors, including year (2009–2013), service (Navy vs. Marine Corps), sex, rank, and deployment history. Supplementary analyses examined MVC rates in three specific locations with high densities of DoN personnel: San Diego, California; Jacksonville, North Carolina; and Norfolk, Virginia.

Methods

Data Sources

Estimating MVC rates based on medical encounters for related injuries required obtaining and merging medical, deployment, and personnel data for all Sailors and Marines on active duty during the study period. The three databases used are described in more detail below. For analytic purposes, databases were merged by matching on personally identifying information (social security number, date of birth, and sex). This information was removed prior to conducting statistical analyses.

***Medical Data*.** TRICARE medical reimbursement data were used to identify all service members who were evaluated or treated for injuries caused by MVCs during the 5-year study period (2009–2013). Medical encounters for MVC-related injuries were also examined for the year preceding the study period (2008). This was done to ensure that medical visits for MVC-related injuries during the study period were not part of continuing treatment of MVC-related injuries that may have occurred prior to the study period.

Medical data for all inpatient and outpatient encounters of active-duty Navy and Marine Corps personnel who were reimbursed through TRICARE Management Activity (TMA) were obtained from the MHS Data Repository. Each encounter during the study period was examined for evidence of MVC-related injury. This was reflected in External Causes of Injury codes (E codes) based on the *International Classification of Diseases, 9th Revision, Clinical Modification*. The codes of interest indicated that the service member was seeking medical care as the result of a motor vehicle traffic accident (E810–E819) or a motor vehicle non–traffic-related accident (E820–E825).

Additional data extracted from the medical files for the first MVC-related visit included the type of visit (inpatient vs. outpatient) and the day of the week of the visit. The date of the medical visit served as a proxy for the date of the MVC itself, which was not reflected in medical records. Also extracted was the type of injury(ies) incurred (fracture: codes 800–829, dislocation: 830–839, sprain: 840–848, intracranial injury: 850–854, abdominal injury: 860–869, open wound: 870–897, blood vessel damage: 900–904, superficial injuries: 910–919, contusion: 920–924, crushing injury: 925–929, foreign body-related injury: 930–939, burn: 940–949, nerve/spinal cord injury: 950–957). Finally, number of injuries was computed by summing the amount of different types of injury reported. Note that this count did not include multiple injuries of the same type because this information was not well-defined in the data.

For each year of the study period, all personnel with one or more medical visits related to an MVC were identified. Repeated visits for MVC-related medical care by the same individual (whether within or across years) were assumed to be related to the same MVC incident; thus, each service member was counted as having only one MVC during the study period, regardless of the number of medical visits. This conservative assumption would underestimate rates of MVCs if a given person was injured in more than one MVC during the study period, but it would ensure that the more likely situation of repeated medical visits for the same crash would not be erroneously counted as new crashes.

Deployment Data. Defense Manpower Data Center (DMDC) Contingency Tracking System data were used to obtain the start and end dates of all deployments in support of the Global War on Terror. These dates were then used to determine whether each service member had returned from deployment in the previous year. For those with an MVC, this was defined as returning from deployment within the 365 days prior to the crash; for those without an MVC, this was defined as returning from deployment during the previous calendar year.

Approximately 1% of the MVC-related encounters over the study period (n = 379) occurred during a deployment (i.e., between the deployment departure and return dates). Because TMA does not routinely maintain records of medical encounters that occur in theater, using these data to compute rates of MVC-related injuries that occur on deployment would result in spuriously low estimates. Consequently, cases in which an MVC-related injury appeared to have occurred during deployment were excluded from all analyses.

Personnel and Demographic Data. Data for all Sailors and Marines who were on active duty at any time during the study period were obtained from DMDC monthly personnel files. The Master File was used to estimate yearly active duty military strength, or the total number of personnel on active duty during each year of the study period. For purposes of the present report, active duty strength for each calendar year was estimated by the number on duty in July of that year. This file also provided descriptive information for each service member, including sex, service branch, pay grade, and duty station.

Three localities were of particular interest based on their relatively large population of Sailors and/or Marines stationed there: San Diego, Jacksonville, and Norfolk. There are high concentrations of both Marines and Sailors in the San Diego County area (e.g., Naval Base San Diego, Marine Corps Recruit Depot San Diego, Naval Base Coronado, Marine Corps Air Station [MCAS] Miramar, and Camp Pendleton, which is the major West Coast base of the Marine Corps. Jacksonville is home to a large population of Marines (primarily at Camp Lejeune, MCAS New River, and neighboring MCAS Cherry Point), as well as a smaller number of Sailors. Conversely, Norfolk has a vast naval footprint and is home to the world’s largest naval station, although the area is also home to a small population of Marines. Hampton Roads in southeastern Virginia (made up of numerous cities: Norfolk, Portsmouth, Newport News, Hampton, Virginia Beach, Chesapeake) is the East Coast epicenter of military activity, and is home to other service branch facilities. To identify service members in specific regions of interest, the zip codes associated with service members' duty stations were examined and classified with reference to (1) DMDC Unit Identification Code address list, (2) base facility identification, and (3) the U.S. Postal Service website. For a list of zip codes used to identify personnel in each region, see the Appendix.

Analyses

The first set of analyses examined characteristics of the first medical encounter that a service member had for MVC-related injuries, including the day of the week on which the encounter occurred, the type of medical care received (inpatient or outpatient), and the type and number of injuries sustained. Throughout this report, type of visit and type and number of injuries are treated as proxies for MVC severity.

The second set of analyses estimated rates of MVCs across the study period, both overall and as a function of year, service (Navy vs. Marine Corps), sex, rank, and deployment history. Supplementary analyses examined MVC rates in three specific locations characterized by large populations of Sailors and/or Marines.

Across both sets of analyses, trends and patterns are noted in the form of incidence counts and odds ratios.[*] However, no formal statistical significance testing was conducted.

*The odds of a given event are determined by comparing the likelihood that the event will occur and the likelihood that it will not occur. For example, if it is two times more likely that the event will occur than not occur, the odds are 2:1. An odds ratio compares the odds of an event occurring across two groups. If the odds of the event occurring are equal in both groups, the odds ratio will equal 1.0. An odds ratio greater than 1 indicates that the odds are higher in the first group than in the second, whereas an odds ratio less than 1 indicates that the odds are higher in the second group. For example, consider an odds ratio comparing the likelihood that Marines versus Sailors sought inpatient medical care. An odds ratio of 2.0 indicates that the odds are twice as high for Marines as for Sailors; an odds ratio of 0.5 indicates that the odds of receiving inpatient care are twice as high for Sailors as for Marines (1/0.5 = 2.0).

Results

Characteristics of MVC-Related Medical Encounters

This section includes information on (1) the day of the week of the first MVC-related medical encounter, (2) the type of medical encounter (inpatient vs. outpatient), (3) the number of different MVC-related injuries sustained, and (4) the types of injuries sustained.

Day of Week. The first analyses examined the day of the week on which initial MVC-related medical encounters occurred. Bear in mind that this is the day of week of the first medical visit related to the MVC, and not necessarily the day on which the MVC occurred. Figure 1 shows the percentage of initial MVC-related medical visits occurring on each day of the week. Overall, medical visits for injuries caused by MVCs were most likely to occur on Mondays, Tuesdays, and Fridays; initial MVC-related medical encounters were least likely to occur on weekends.

Figure 1. Percentage of Initial Medical Encounters for MVC-Related Iniuries bv Dav of Week

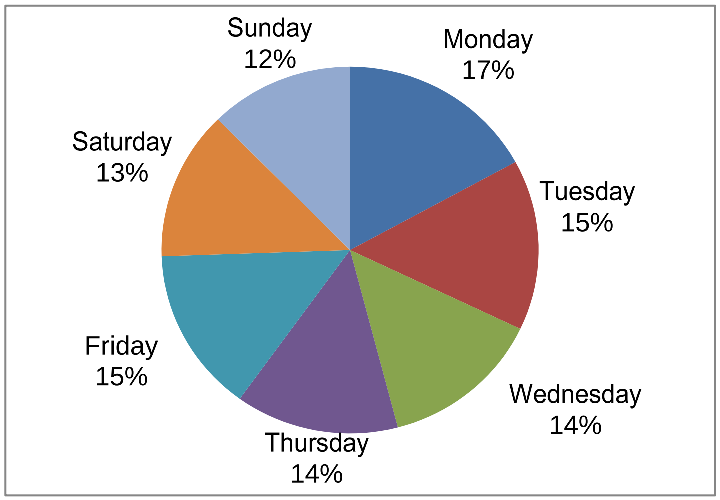


Figure 2. Percentage of Initial Medical Encounters for MVC-Related Injuries by Day of Week and Service

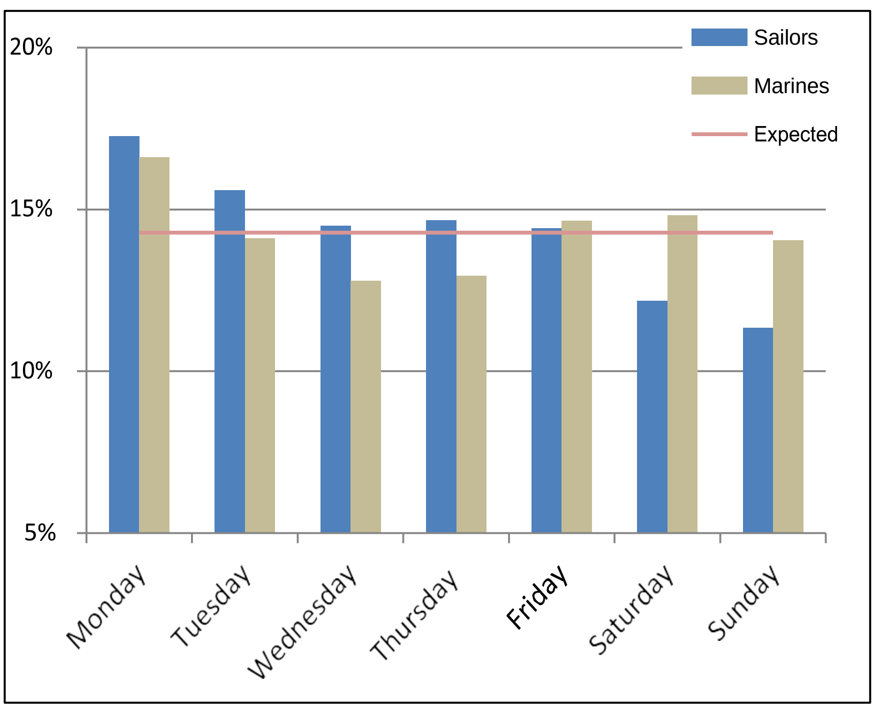
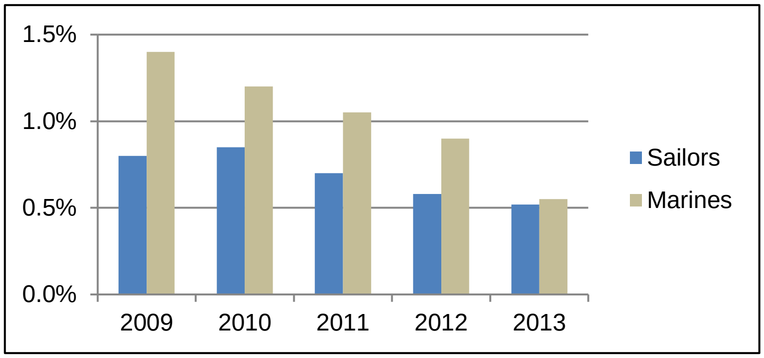


Figure 2 shows the distribution of first MVC-related medical visits by day of week across the 5-year study period, separately for Navy and Marine Corps personnel. In the figure, the line labeled “Expected” shows the percentage of visits that would occur on each day if medical care-seeking were unrelated to the day of the week.

As Figure 2 shows, Sailors were particularly likely to seek medical care for MVC-related causes on Mondays and Tuesdays, and unlikely to seek care on weekends. Marines were particularly likely to seek medical care for MVC-related causes on Mondays, and particularly unlikely to seek care midweek (i.e., on Wednesdays and Thursdays).

Figure 3. Percentage of Initial Inpatient Medical Encounters for MVC-Related Injuries by Year



Type of Medical Encounter. Of a total of 30,696 service members who sought medical care for an MVC-related injury, only 250 (0.8%) first sought inpatient care. Marines were more likely than Sailors to seek inpatient care for MVC-related injuries (1.1% vs. 0.7%, respectively; odds ratio [OR] = 1.58). As shown in Figure 3, the difference between services diminished over time, primarily as a result of decreased use of inpatient care among Marines.

Type of Medical Encounter by Day of Week. To explore whether patterns of MVC-related medical visits across days of the week differed for inpatient versus outpatient visits, additional analyses were conducted. The day of the week on which initial inpatient medical encounters related to MVCs occurred is provided in Figure 4a; the day of the week on which initial outpatient medical encounters related to MVCs occurred is provided in Figure 4b. In either case, results are provided separately for Sailors and Marines. As in Figure 2, the line labeled “Expected” shows the percentage of visits that would be expected to occur on each day if medical encounters were equally likely to occur on each day of the week.

Figure 4a. Percentage of Initial Inpatient Medical Encounters for MVC-Related Injuries by Day of Week and Service

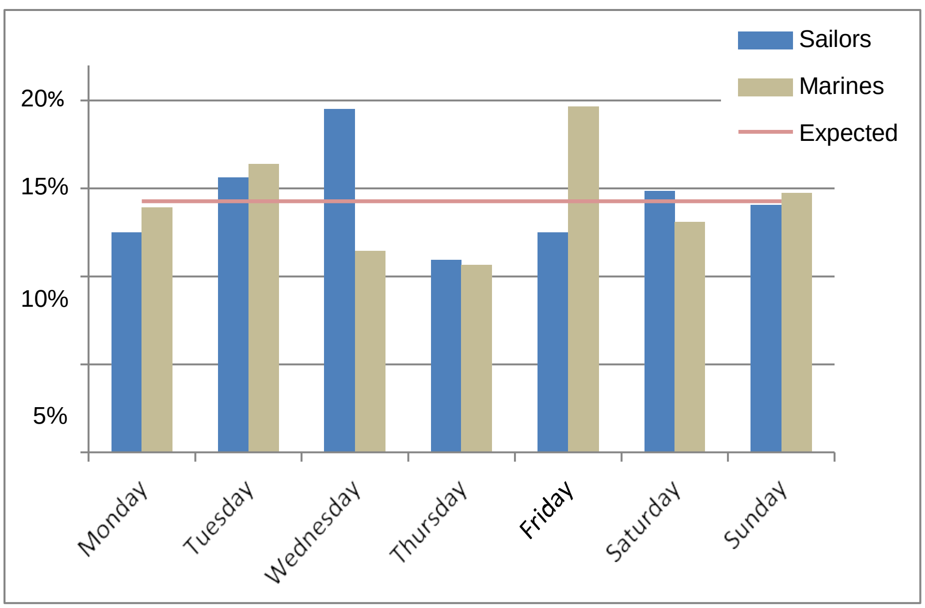
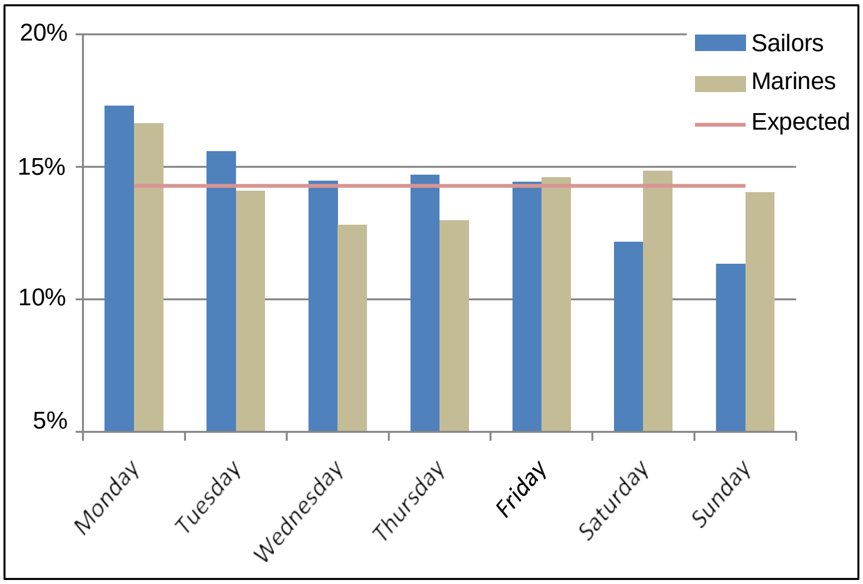


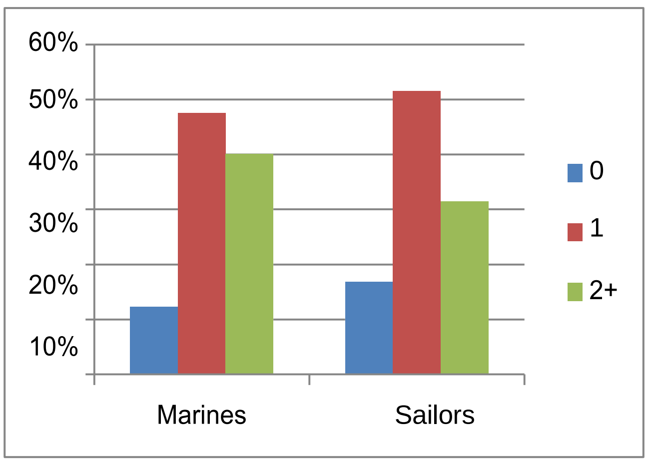
Figure 4a shows that members of both services were unlikely to seek inpatient care for an MVC-related injury on Thursdays. Sailors were particularly likely to seek inpatient care on Wednesdays and unlikely to seek it on Fridays, whereas Marines were particularly likely to seek inpatient care on Fridays and unlikely to seek it on Wednesdays.

Figure 4b. Percentage of Initial Outpatient Medical Encounters for MVC-Related Injuries by Day of Week and Service



Initial outpatient visits for injuries related to MVCs (Figure 4b) were most likely to occur on Mondays, perhaps suggesting elevated weekend rates of MVCs. For Sailors, initial outpatient visits for an MVC-related injury were least likely on weekends; for Marines, they were least likely midweek (Wednesday or Thursday).

Figure 5. Number of MVC-Related Injuries by Service



Number and Type of MVC-Related Injuries. Figure 5 shows that Sailors generally had fewer MVC-related injuries than Marines. Specifically, Sailors were more likely than Marines to have zero injuries (16.9% vs. 12.3%) or one injury: 51.6% vs. 47.6%), whereas Marines were more likely than Sailors to suffer multiple (two or more) injuries (40.1% vs. 31.5%). The odds of multiple injuries were 1.45 times higher among Marines compared with Sailors.

The most common types of injuries for those in either service included sprains, contusions, fractures, and superficial injuries. Of these, only sprains were more common among Sailors than Marines. The injuries with the largest difference in incidence magnitude across services (as indicated by odds ratios) included crushing injuries, nerve/spinal cord injuries, dislocations, and intracranial injuries, all of which were more commonly found in Marines than in Sailors (Table 2). These results suggest that Marines may have had more-severe MVCs and ensuing injuries overall.

Table 2. Type of Injury by Service

	% Marine Corps	% Navy	Odds Ratio
Sprain	33.07	38.67	0.78
Contusion	22.74	20.31	1.15
Fracture	18.89	12.49	1.63
Superficial	17.23	12.51	1.46
Open wound	11.40	7.23	1.65
Intracranial	6.83	4.11	1.71
Dislocation	3.41	2.02	1.71
Abdominal	2.79	2.02	1.39
Crushing injury	0.79	0.37	2.14
Nerve/spinal cord	0.57	0.33	1.73
Blood vessel	0.29	0.18	1.61
Burn	0.28	0.42	0.67
Foreign body	0.10	0.06	1.67

Estimated Rates of MVC-Related Medical Encounters

The remaining analyses examined rates of MVCs overall and as a function of service member characteristics across the 5-year study period (2009–2013). Characteristics examined included branch of service, sex, rank, and previous deployment. In addition, MVC rates were examined in three specific locations with high-density DoN representation.

Branch of Service. Across the study period, a total of 30,696 active-duty DoN personnel had one or more medical visits for an MVC-related injury (19,112 Sailors, 11,584 Marines). The total number of MVCs per year ranged from a high of 6,495 (in 2009) to a low of 5,691 (in 2013). Table 3 provides the average number of MVCs per year for the total DoN sample, as well as separately for the Navy and Marine Corps. The table also shows the average annual active duty strength across the study period. The active duty strength estimates the number of service members on duty each year, and serves as the denominator in calculating MVC rates.

Table 3. Average Yearly MVCs and Active Duty Strength by Service

	Navy		Marine Corps		Total	
	M	SD	M	SD	M	SD
MVCs	3,822	111	2,317	238	6,139	323
AD strength	321,884	4,066	199,926	4,299	521,809	8,171

Note. AD = active duty; M = mean; MVC = motor vehicle crash; SD = standard deviation.

Averaging across the 5-year study period, the rate of MVCs was 1.2% for both Sailors and Marines, indicating that slightly more than 1 of every 100 active duty service members in either branch was injured in a MVC each year. However, one noteworthy difference between the two services is the greater variability over time in number of MVCs for Marines. This is reflected in the higher standard deviation (SD) for MVCs among Marines than Sailors (SD = 238 vs. 111, respectively; see Table 3).

Figure 6. MVC Rates by Branch of Service

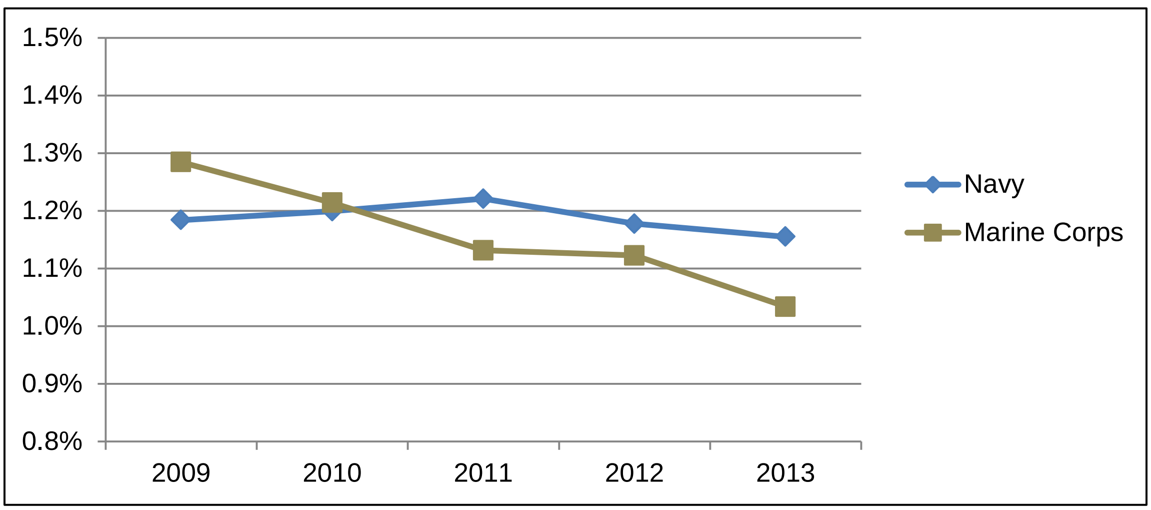


Figure 6 shows changes in MVC rates across the study period. The DoN as a whole experienced a slight decline in MVC rates of about 0.1% over the 5 years in question. As is clear from the figure, however, the decline was more pronounced among Marines than Sailors. MVC rates among Sailors were fairly consistent across the study period, whereas MVC rates among Marines steadily declined. As a result, although Marines had higher MVC rates than Sailors at the beginning of the study period, they had lower rates by the end.

Sex. The next set of analyses examined sex differences in MVC rates. Overall, women had 6,347 MVCs during the study period, while men had 24,349 MVCs. Table 4 provides the average numbers of MVCs and active duty strength per year as a function of sex and branch of service.

MVC rates were nearly twice as high for women as men (1.9% vs. 1.1%, respectively). The sex gap was larger in the Navy (2.0% vs. 1.0%) than in the Marine Corps (1.8% vs. 1.1%).

Table 4. Average Yearly MVCs and Active Duty Strength by Sex and Service

	Navy		Marine Corps		Total	
	M	SD	M	SD	M	SD
Men						
MVCs	2,795	117	2,075	231	4,870	333
AD strength	269,234	6,036	186,318	4,748	455,552	10,730
Women						
MVCs	1,027	29	242	15	1,269	30
AD strength	52,488	2,058	13,607	488	66,095	2,529

Note. AD = active duty; M = mean; MVC = motor vehicle crash; SD = standard deviation.

Figure 7. MVC Rates by Sex and Branch of Service

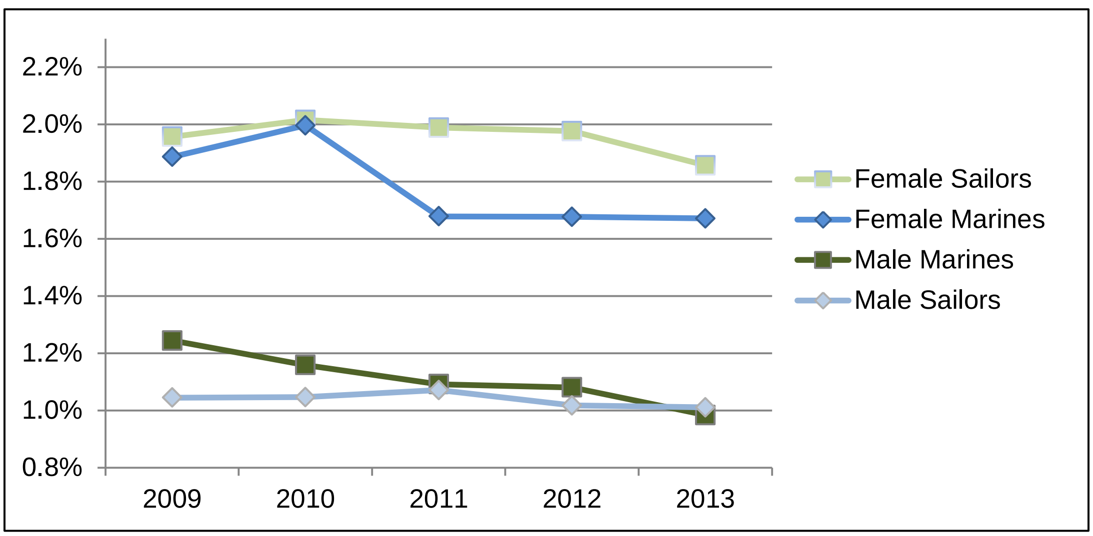
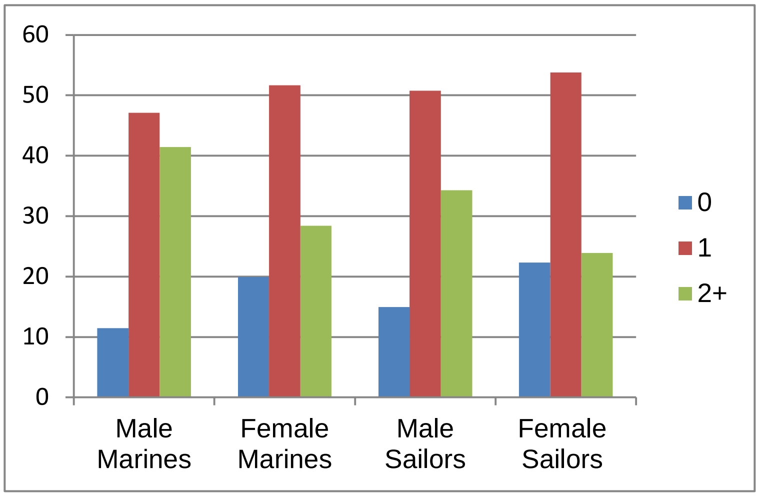


Figure 7 displays changes in MVC rates over time for male and female Sailors and Marines. The figure clearly shows a higher MVC rate among women in either service compared with their male counterparts. Consistent with Figure 6, MVC rates for Sailors remained relatively stable over time, while rates for Marines (especially women) exhibited reduction.

Sex and Injury Severity. Within either service, men had a greater percentage of multiple (two or more) injuries (Figure 8) and proportionately greater use of inpatient services than did women (Marines: 1.1% vs. 0.3%, OR = 3.48; Sailors: 0.7% vs. 0.5%, OR = 1.58). This suggests that men may have had more-severe MVC-related injuries. Overall, male Marines had the highest incidence on both metrics, followed by male Sailors.

Figure 8. Number of MVC-Related Injuries by Service and Sex



Tables 5a and 5b show the odds ratios and frequencies for each specific type of injury, broken down by service and sex. Within both services, men were more likely than women to be diagnosed with most types of injuries; the only exceptions were sprains (women in either service had a higher incidence) and burns (female Marines had a higher incidence, but female Sailors did not). Thus, the four types of injuries that appear to be most serious (nerve/spinal cord damage, crushing injury, intracranial injury, and fracture) were more commonly found in men than in women, but so were many of the injuries that appear to be less serious.

Among Marines, the largest sex differences (as indicated by odds ratios) were observed for abdominal injuries, dislocations, and blood vessel damage, all of which were more common in men. Among Sailors, the greatest sex differences were seen for dislocations, blood vessel damage, and fractures, only the latter of which was more common among women.

Table 5a. Type of Injury by Sex, Marine Corps

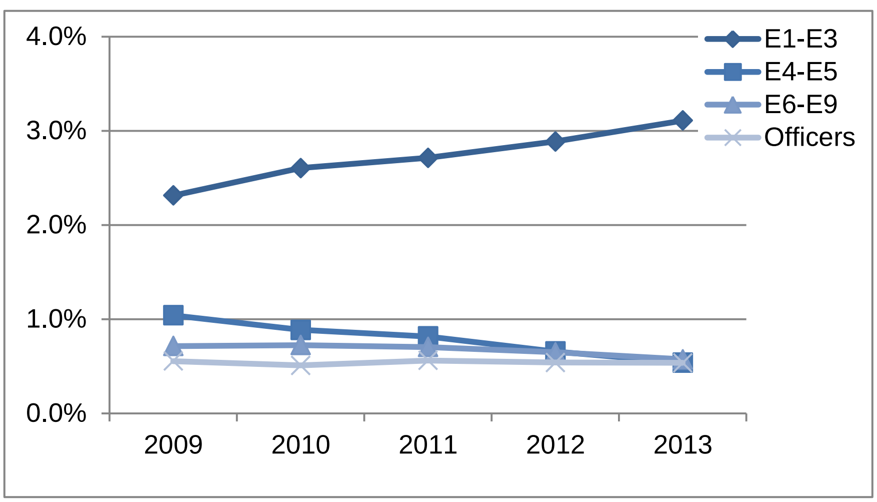
	Odds Ratio	% Men	% Women
Abdominal	63.10	3.06	0.05
Dislocation	11.83	3.77	0.33
Blood vessel	4.01	0.32	0.08
Open wound	3.63	12.3	3.72
Fracture	3.30	19.94	7.02
Superficial	2.25	18.19	9.01
Intracranial	2.01	7.19	3.72
Contusion	1.27	23.15	19.17
Crushing	1.21	0.80	0.66
Nerve/spinal cord	1.16	0.58	0.50
Sprain	0.68	32.15	40.99
Burn	0.43	0.25	0.58
Foreign body	–	0.12	0.00

Table 5b. Type of Injury by Sex, Navy

	Odds Ratio	% Men	% Women
Dislocation	6.18	2.60	0.43
Blood vessel	6.01	0.24	0.04
Fracture	4.26	15.56	4.15
Nerve/spinal cord	4.21	0.42	0.10
Superficial	3.46	15.28	4.96
Open wound	3.21	8.81	2.92
Abdominal	3.06	2.47	0.82
Crushing	2.45	0.44	0.18
Intracranial	2.27	4.82	2.18
Foreign body	1.75	0.07	0.04
Burn	1.40	0.46	0.33
Contusion	1.20	21.08	18.22
Sprain	0.69	36.26	45.22

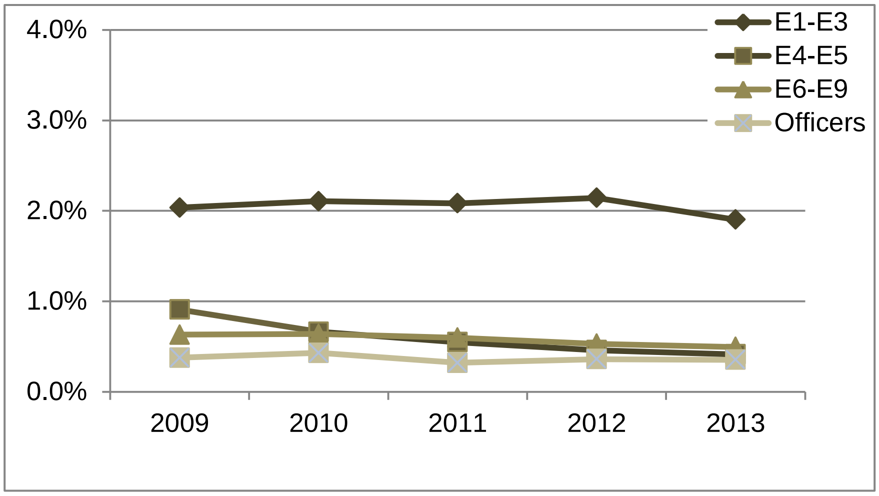
Rank. The next set of analyses examined whether MVC rates varied as a function of military rank. Across the study period, junior enlisted service members (E1–E3) had a total of 18,858 MVCs. In contrast, all higher ranks combined had less than half as many MVCs (total *n* = 11,838, including 6,513 E4–E5, 3,483 E6–E9, and 1,842 officers). Consistent with this, MVC rates were substantially higher for junior enlisted (2.4%) than for any other group. In fact, MVC rates for each of the other rank groups were less than 1 in 100 (E4–E5: 0.7%, E6–E9: 0.6%, officers: 0.5%).

Figure 9a. MVC Rates by Rank, Navy



MVCs among personnel of different ranks over time are shown separately for Sailors (Figure 9a) and Marines (Figure 9b). The higher rate of MVCs among junior enlisted personnel is evident for both services, but more so in the Navy relative to the Marine Corps (2.7% vs. 2.0%, respectively).

Figure 9b. MVC Rates by Rank, Marine Corps



Figures 9a and 9b also show that MVC rates for junior enlisted personnel increased over the study period for Sailors (from 2.3% to 3.1%), but not for Marines. In contrast, within both services, MVC rates among mid-level (E4–E5) and senior enlisted (E6–E9) personnel decreased over time, to the point that 2013 MVC rates were essentially equivalent for all ranks other than junior enlisted, at approximately 0.5%.

Rank and Injury Severity**.** Within both services, junior enlisted personnel had more-severe MVC-related injuries than their senior enlisted/officer counterparts, as indicated by their proportionally greater use of inpatient medical care (Marines: 1.1% vs. 0.9%, OR = 1.22; Sailors: 0.7% vs. 0.6%, OR = 1.11) and higher numbers of multiple injuries (Marines: 40.7% vs. 38.6%, OR = 1.09; Sailors: 31.3% vs. 30.2%, OR = 1.05; Figure 10). However, these differences in injury severity metrics were quite modest. Moreover, by either metric, both junior and senior personnel in the Marines had a higher incidence of severe injuries than did Sailors of any rank.

Figure 10. Number of MVC-Related Injuries by Service and Rank

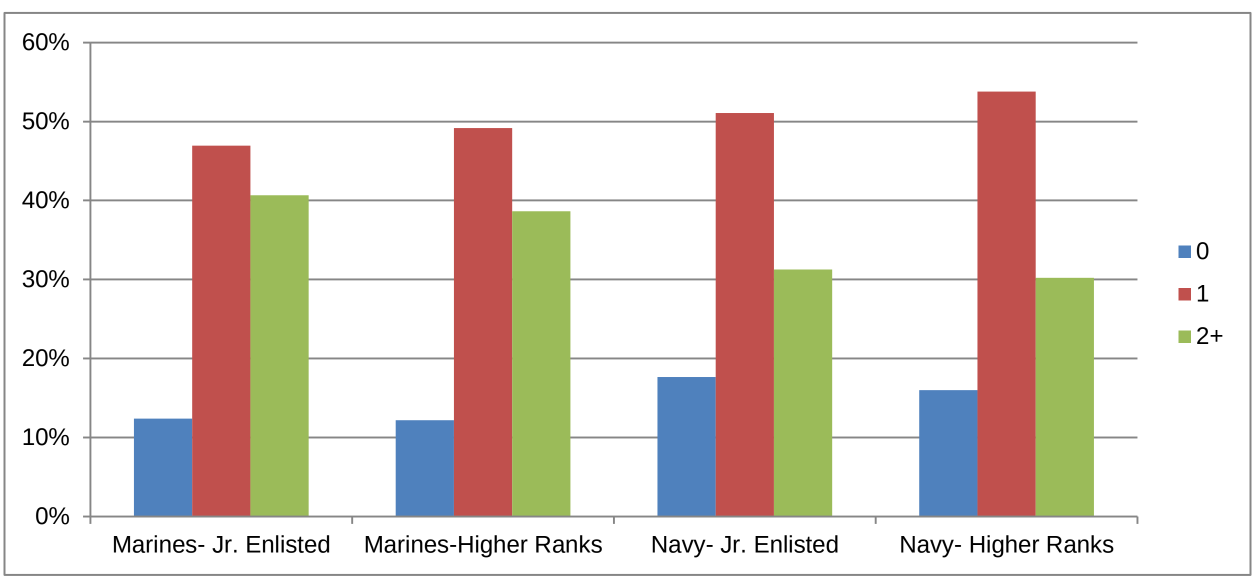


Table 6a. Type of Injury by Rank, Marine Corps

	Odds Ratio	% Jr. Enlisted	% Higher Rank
Blood vessel	2.34	0.35	0.15
Abdominal	1.51	3.08	2.06
Intracranial	1.50	7.51	5.12
Superficial	1.27	18.16	14.9
Open wound	1.25	12.03	9.84
Foreign body	1.22	0.11	0.09
Crushing	1.17	0.82	0.70
Nerve/spinal cord	1.07	0.58	0.54
Contusion	1.03	22.88	22.37
Sprain	0.88	32.23	35.18
Fracture	0.87	17.99	20.1
Burn	0.69	0.25	0.36
Dislocation	0.63	2.93	4.60

Similarly, differences between junior enlisted personnel and senior enlisted/officers in the odds of specific types of injuries were generally modest in both branches (see Tables 6a and 6b). Among Marines, the largest differences were found for blood vessel, abdominal, and intracranial injuries (all of which were more common among junior enlisted personnel), and dislocations (which were more common in higher ranks). Among Sailors, the largest differences were observed for burns, blood vessel damage, and crushing injuries (all of which were more common in junior enlisted personnel) and foreign body injuries (which were more common in higher ranks).

Table 6b. Type of Injury by Rank, Navy

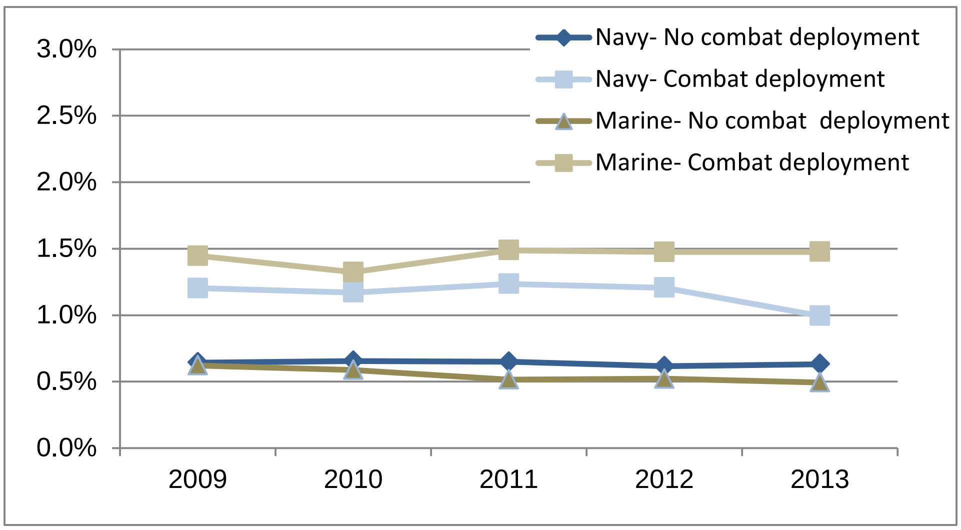
	Odds Ratio	% Jr. Enlisted	% Higher Rank
Burn	1.60	0.51	0.32
Blood vessel	1.40	0.21	0.15
Crushing	1.31	0.42	0.32
Contusion	1.10	21.03	19.43
Abdominal	1.10	2.11	1.92
Open wound	1.07	7.43	6.97
Intracranial	1.05	4.20	4.01
Superficial	1.04	12.69	12.29
Nerve/spinal cord	1.03	0.34	0.33
Sprain	0.87	37.18	40.53
Fracture	0.70	10.77	14.63
Dislocation	0.67	1.66	2.46
Foreign body	0.62	0.05	0.08

***Deployment History*.** The next set of analyses examined whether previous deployment was associated with increased rate of MVCs, as some previous research has suggested.[13,14] This issue was addressed by comparing MVC rates among service members who had versus those who had not returned from a deployment in support of the Global War on Terror within the previous year.

Return from deployment in the previous year was associated with elevated rates of MVCs. The overall MVC rate was 1.3% among service members who had returned from deployment in the past year compared with 0.6% for those who had not. The magnitude of the difference in MVC rates was similar between Sailors (1.2% vs. 0.6%) and Marines (1.4% vs. 0.5%).

Figure 11 shows changes in rates of MVCs over time as a function of past-year deployment. Among those who returned from deployment within the past year, MVC rates were slightly higher among Marines than Sailors. MVC rates among those in either service who had not deployed were very similar.

Figure 11. MVC Rates by Service and Past-Year Deployment



***Location*.** The final set of analyses examined MVC rates in three localities of particular interest because of their high concentrations of DoN personnel: San Diego, Jacksonville, and Norfolk. For each of these three locations, Table 7 provides the average number of MVCs per year and the average yearly active duty strength. Overall, the MVC rate was highest in San Diego (1.2%), followed by Norfolk (1.0%), and Jacksonville (0.9%). For comparison, recall that the overall MVC rate for DoN personnel during the 5-year study period was 1.2%.

Table 7. Average Yearly MVCs and Active Duty Strength by Location

	San Diego, CA		Jacksonville, NC		Norfolk, VA	
	M	SD	M	SD	M	SD
AD strength	84,588	1,985	59,318	2,108	35,827	1,034

Note. AD = active duty; M = mean; MVC = motor vehicle crash; SD = standard deviation.

Figure 12. MVC Rates in Three Locations

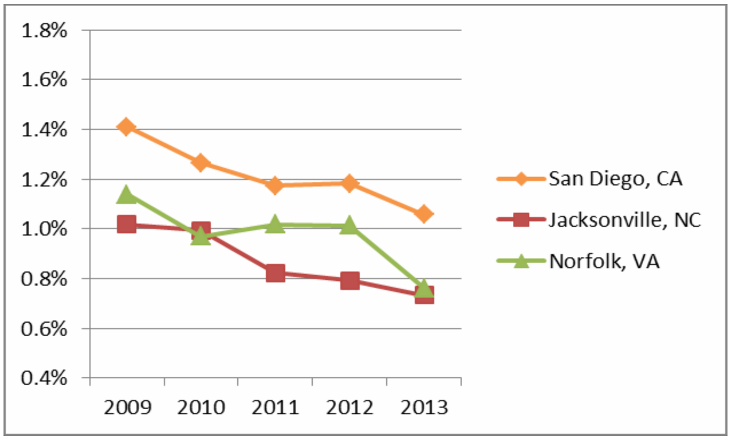


Figure 12 shows changes over time in MVC rates in the three locations of interest. As is shown, MVC rates decreased over time in all three localities.

Table 8 provides yearly average number of MVCs and yearly average active duty strength for each location by service. For both services, rates were lowest in Jacksonville (0.9%).

Table 8. Average Yearly MVCs and Active Duty Strength by Location and Service

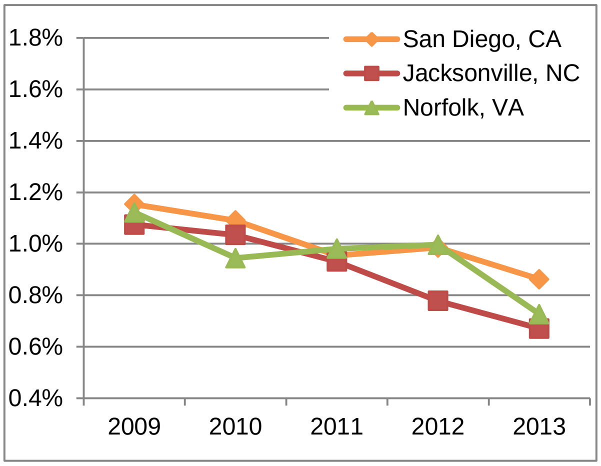
	San Diego, CA		Jacksonville, NC		Norfolk, VA	
	M	SD	M	SD	M	SD
Navy						
MVCs	304	40	37	7	315	52
AD strength	30,093	914	4,126	76	32,956	832
Marine Corps						
MVCs	727	89	482	84	37	5
AD strength	54,495	1,280	55,192	2,122	2,870	217

Note. AD = active dutv: M = mean: MVC = motor vehicle crash: SD = standard deviation.

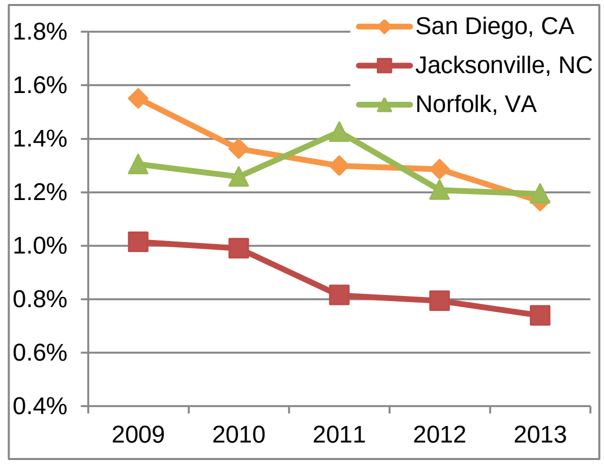
Changes over time in MVC rates in the three locations of interest are shown by service branch in Figures 13a and 13b. Reductions in MVC rates over time were evident for both services and all three locations, with the exception of Marines in Norfolk. It should be noted, however, that this estimate is based on the smallest sample of any in the table (only 2,870 total), and it is therefore likely to be less precise and stable than the other estimates.

Figure 13. MVC Rates in Three Locations

a. Navy



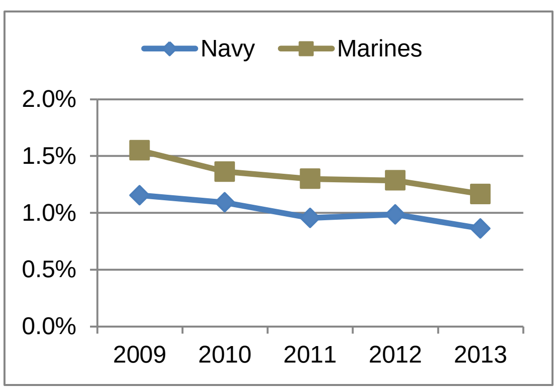
b. Marine Corps



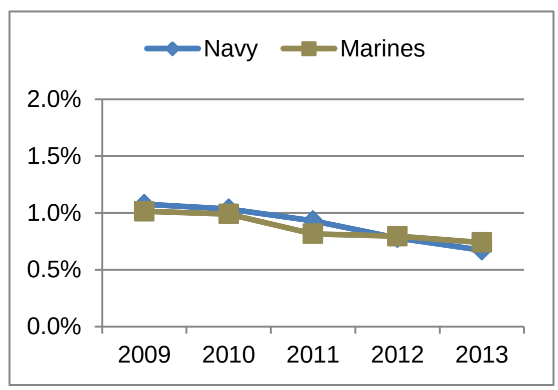
Figures 14a to 14c highlight cross-service comparisons of changes in MCV rates from 2009 to 2013 in each location of interest. Figures 14a and 14c show that Marines had higher rates of MVCs than Sailors at two of the three sites (San Diego and Norfolk). In contrast, rates of MVCs in Jacksonville were very similar for both service branches (Figure 14b).

Figure 14. MVC Rates in Each Location by Service

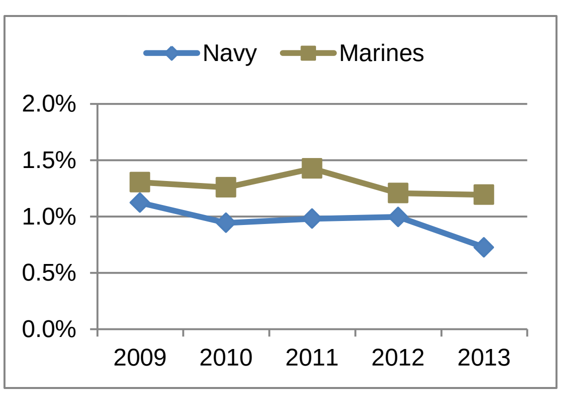
a. San Diego, CA



b. Jacksonville, NC



c. Norfolk, VA



Discussion

Summary of Findings

The present analyses revealed a number of interesting findings about MVC rates as estimated by medical encounter data. These are briefly discussed below.

- ***MVC Injury Severity*.** Analyses included three indicators of MVC severity: number of injuries, type of injuries, and receipt of inpatient medical care. Most service members were diagnosed with one type of injury (51.6% of Sailors and 47.6% of Marines), although diagnoses of no injuries (16.9% of Sailors and 12.3% of Marines) or two or more types of injuries (31.5% of Sailors and 40.1% of Marines) were not uncommon. The most common types of injuries included sprains, contusions, fractures, and superficial injuries. Less than 1% of initial MVC-related medical encounters were inpatient in nature.

- ***Branch of Service Differences*.** Overall rates of MVCs were 1.2% in both the Navy and the Marine Corps. Compared with Sailors, Marines scored higher on the accident severity indicators, suggesting that Marines, on average, may be involved in more-serious MVCs. However, the rate of inpatient service use among Marines steadily decreased over the 5-year study period, which may indicate reductions in MVC severity among Marines over time.

- ***Sex Differences*.** MVC rates were consistently higher among women than men across the study period. However, previous research suggests two reasons why this observed difference may not reflect actual sex differences in MVC rates: first, women are more likely than men to sustain serious injuries in MVCs because of their smaller stature,[15,16] and second, women are more likely than men to seek medical care, regardless of injury status.[17] This study provides results consistent with the second explanation. The present findings that women sustained fewer injuries and sought less inpatient medical care than men may reflect women's greater use of health care, even for less severe injuries, rather than true sex differences in MVC rates. For these reasons, sex comparisons of MVC rates based on medical data are likely to be problematic.

- ***Rank Differences*.** Consistent with previous research, junior enlisted personnel were at elevated risk of MVCs compared with senior enlisted personnel and officers.[13,14] In addition, junior enlisted personnel were more likely than their senior counterparts to have severe MVCs, as indicated by the percentage using inpatient medical services and number of injuries sustained. The magnitude of these differences was small, however. Rates of medical visits for MVCs among junior enlisted personnel were higher in the Navy than in the Marine Corps.

- ***Deployment Effects.*** Consistent with previous research,[13,14] DoN personnel who had returned from a deployment in support of the Global War on Terror during the past year had higher rates of MVCs than those who had not. Also consistent with previous research,[13] the effect of deployment on MVCs appeared to be greater for Marines than Sailors.

- ***Geographic Differences.*** Overall, DoN MVC rates were highest in San Diego, followed by Norfolk, and then Jacksonville. The range of MVC rates within service across locations was larger among Marines than Sailors. In addition, the difference in MVC rates between Marines and Sailors varied by location. In Jacksonville, rates were nearly identical for both services; in contrast, Marines had higher rates of MVCs than did Sailors in both San Diego and Norfolk.

- ***Time Effects***. Previous reports have noted decreasing rates of MVCs for the period from 1980–2010.[2] The present report shows continuing reductions in MVC rates between 2009 and 2013. The present analyses revealed several factors associated with changes in MVCs over time:

  - Reductions in MVCs over time were more pronounced in the Marine Corps than in the Navy.
  - Reductions in MVCs over time were greater for female Marines than for male Marines.
  - MVC rates increased over time among junior enlisted Sailors, but not among junior enlisted Marines.
  - The increased risk of MVCs among personnel who returned from deployment in the previous year decreased over time for Sailors, but not for Marines.

Implications and Recommendations

Branch of Service. The evidence indicates that Marines generally had more-severe MVCs than Sailors. However, rates of MVCs and severity of MVC-related injuries (as indicated by inpatient medical visits) among Marines decreased over time, suggesting that existing interventions targeting Marines may be effective in reducing MVC rates. Systematic review of between-service differences in MVC-related policies and procedures, as well as changes in these policies and procedures over time, should be conducted in an attempt to determine why this decrease was more pronounced for Marines, and especially female Marines, than for Sailors.

Junior Enlisted Personnel. Although preliminary, the present results have several implications. First, heightened rates of MVCs, as well as more-severe MVCs, among junior enlisted (E1–E3) personnel suggest that efforts to reduce MVCs should target this group in particular. Further, given that rates of MVCs among junior enlisted were consistently higher in the Navy compared with the Marine Corps, interventions targeting junior enlisted Sailors may have more potential to reduce MVC rates than interventions targeting junior enlisted Marines. Systematic analysis and cross-service comparison of existing MVC prevention programs and policies, and of changes in these programs and policies over time, may help to illuminate reasons for cross-service differences in patterns of MVCs among junior enlisted personnel.

***Recently Deployed Personnel*.** Higher rates of MVCs among personnel recently returned from deployment suggest that interventions targeting this population have the potential to significantly reduce MVC rates in the DoN overall. Because effects of deployments on MVC rates appear to be greater for Marines than Sailors, interventions targeting returning Marines may be particularly effective in reducing MVC rates.

***Geographic Differences*.** The present investigation focused on three geographic regions marked by high concentrations of DoN personnel: San Diego, Jacksonville, and Norfolk. Future investigations should examine this issue more broadly, across a range of duty locations. In addition, attributes of these locations that might bear on rates of MVCs should be examined to determine whether these environmental factors can explain regional differences in MVC rates.

Strengths and Limitations

***Using Medical Data to Estimate Motor Vehicle Crash Rates*.** The present effort was a limited-duration feasibility study designed to examine how records of TRICARE-reimbursed medical encounters might be used in MVC surveillance. The findings described above support the feasibility of this approach. However, it is important to bear in mind that estimates of MVC rates based solely on medical data will underestimate true rates of MVCs for several reasons. First, some MVCs do not produce injuries and therefore would not require medical attention. Second, individuals who are injured in MVCs may not seek medical attention, or may do so outside of the MHS. Third, providers may fail to note the cause of injury within the individual's medical chart. Previous researchers have noted that E codes may not be well-populated in medical databases.[19] Moreover, the extent to which E codes are consistently and accurately used may differ by service and medical treatment facility.

MVC rates estimated using medical encounter data also may be biased by individual differences in (a) likelihood of sustaining injuries in MVCs, and/or (b) likelihood of seeking medical attention for injuries sustained in MVCs. That is, differences in health care visits for MVC-related injuries may not be a pure reflection of differences in MVC rates because they are influenced by other factors (e.g., sex).

Despite these limitations, using medical encounter data to estimate MVC rates has advantages. Foremost among these is the fact that all service member medical encounters reimbursed through TRICARE are automatically recorded and available for analysis. This contrasts with the Service Safety databases, which require additional data entry. This difference in record-keeping procedures likely accounts for disparities in computed MVC rates between the two data sources.[9,19]

The relative strengths and weaknesses of Service Safety databases and medical encounter databases with respect to identifying MVC-related injuries have not been fully explored. To the extent that each database has complementary strengths, limitations, and biases, the optimal method for estimating MVC rates may require combining information from both data sources. Further research that compares the cases identified in these data sources would help to offset the biases inherent in estimates from either data source alone. This research may also be able to develop algorithms that use both sources of data to maximize accuracy in estimating MVC rates.

Scope. As a short-term feasibility study, the scope of the present report is limited in several respects. First, the analyses reported here cover a relatively short time period (5 years). Second, this investigation considered only a small number of factors that may be related to MVC rates (year, service, sex, rank, recent deployment) and only three locations. A number of additional potential risk or protective factors for MVCs could readily be examined with available data. These include additional demographic factors (e.g., marital status, race, age, Armed Forces Qualification Test scores), military factors (e.g., Military Occupational Specialty, years of service), deployment-related factors (e.g., total number of previous deployments, location, duration, time since return from deployment), medical factors (e.g., prior diagnoses of physical or mental health problems, including traumatic brain injury, posttraumatic stress disorder, substance abuse problems; prescription medication use), installation-level factors (e.g., size, region, remoteness), and other environmental factors (e.g., season, time of day, location).

Variation Across Types of Motor Vehicle Crashes. Previous research suggests that different types of MVCs may be predicted by different risk factors.[19–21] However, in the present study, no attempt was made to classify MVCs based on factors such as type of crash (e.g., single vs. multiple vehicle), type of vehicle (e.g., military vs. private, automobile vs. motorcycle), or role in mishap (driver vs. passenger). Medical encounter databases contain information about some, but not all, of these factors. This is another reason why combining medical and service-specific safety data may be advantageous.

Computation of Rates. As a short-term feasibility study, the present analysis computed crude MVC rates based on the estimated number of personnel on duty each year. A more precise approach would involve calculating the total number of days on duty for each service member during each year, and using person-days as a denominator in calculating rates.

Similarly, a more comprehensive effort would examine the impact of each predictive factor on MVC rates, while controlling for other factors that may constitute confounders (e.g., how much MVC rates vary by sex after controlling for rank, deployment). Finally, a thorough assessment of factors influencing MVC rates would involve statistical significance testing, estimation of effect size, and modeling techniques, all of which would bear on the strength and robustness of observed patterns and differences.

In this study, individuals were assumed to have only one MVC, despite the number of medical records they had related to their care. To examine the impact of this assumption on estimated MVC rates, the number of service members with MVCs was recalculated using a less stringent criterion: if there was a gap of 12 months between medical visits for an MVC-related injury, it was assumed that there had been a new MVC. Using this assumption, the total estimated number of MVCs among DoN personnel increased from 30,696 to 32,022, and the average number per year changed from to 6,139 to 6,404 (a 4% increase in the estimated number of MVCs). However, this has no discernible impact on overall estimated rates of MVCs, which remained at 1.2%. Thus, it does not appear that our rate estimates are substantially biased by the rule originally used to define "new" MVCs.

Future Research Directions

A number of future research directions could inform DoN safety efforts to reduce rates of MVCs by providing an empirical foundation for evidence-based interventions, practices, and policies. These are briefly described below.

***Expanding Current Investigation*.** The current, limited-duration, feasibility study could be broadened in scope and comprehensiveness to examine (a) trends across a longer time span, (b) a broader range of possible risk and protective factors for MVCs, (c) possible differences in risk and protective factors for different types of MVCs, (d) more precise rate estimates based on person-years rather than active duty strength, (e) multivariable effects of specific risk/protective factors after controlling for the effects of other risk/protective factors, and (f) statistical significance and magnitude of effects for particular risk/protective factors.

***Optimizing Estimates of Motor Vehicle Crashes*.** Using multiple sources of data to develop an optimal algorithm for estimating rates of nonfatal MVCs would increase accuracy in tracking changes in rates over time, and assess changes in rates as a function of safety trainings and/or policy changes. This line of effort would provide an evidentiary base documenting the effectiveness of particular policies or educational interventions. It also is likely to identify gaps and weaknesses in current epidemiological databases that track these types of reports, leading to recommendations for system improvements.

Standardizing Reporting. Developing an ongoing process for generating regular reports on MVC rates and characteristics, using an algorithm such as the one described above, would involve (a) creating valid, standardized reporting metrics, (b) providing a foundation for strategic planning to mitigate factors adversely affecting MVC rates by developing trainings and/or policy changes, and (c) facilitating communication of findings regarding DoN MVC rates to policy makers and other stakeholders.

Large-Scale MVC Survey. It is likely that all existing sources of data regarding rates of MVCs suffer from a common limitation: relatively minor MVCs are unlikely to be included. To determine the magnitude of this bias, a one-time, anonymous survey of Sailors and Marines could be conducted. The survey would be administered to a sample of service members in classroom settings, by mail, or via the internet. The survey should include detailed questions about MVCs experienced as a passenger or driver while in the military. Additional questions should assess potential risk and protective factors and background demographic and military information. MVC rates derived from survey responses could be compared with rates estimated using existing databases. Survey data could also be used to develop more detailed predictive risk models as well as strategies for preventing specific types of MVCs.

Systematic Review of Evidence on Military Motor Vehicle Crashes and Prevention Training. An important adjunct to any examination of existing safety data is a review of empirical literature, both military and civilian, regarding predictors and effective approaches to preventing MVCs. A comprehensive review of this nature can help to identify gaps not covered by existing training or policy and can serve as a guide to best practices for mishap prevention trainings that are applicable to military settings.

Conclusions

The present effort demonstrates the feasibility of using medical encounter data to estimate rates of MVCs. However, this investigation is just an initial step toward developing a more accurate and efficient strategy for estimating MVC rates, understanding individual- and installation-level risk factors for specific types of MVCs, and developing and targeting effective strategies that will have maximal impact in reducing rates of MVCs within the DoN.

Because MVCs are a leading cause of DoD medical encounters and lost work days, anything that reduces MVCs among Sailors and Marines has the potential to dramatically improve their overall health and readiness. Given the devastating effects of mishaps on individual military members, as well as the immense financial and readiness costs of accidental injuries to the Navy and Marine Corps, greater empirical attention to this issue is long overdue.

References

1. Sleet DA, Baldwin G. It wouldn't hurt to create a safer military. *Am J Prev Med*. 2010;38(suppl 1):S218-221.
2. Defense Manpower Data Center. Active Duty Military Deaths by Year and Manner, 1980–2010. https://www.dmdc.osd.mil/dcas/pages/report_by_year_manner.xhtml. Accessed July 27, 2015.
3. Powell KE, Fingerhut LA, Branche CM, Perrotta DM. Deaths due to injury in the military. *Am J Prev Med.* 2000;18(suppl 3):S26-32.
4. Armed Forces Health Surveillance Center. Surveillance snapshot: manner and cause of death, active component, U.S. Armed Forces, 1998–2013. *MSMR.* 2014;21(10):21.
5. Jones BH, Canham-Chervak M, Canada S, Mitchener TA, Moore S. Medical surveillance of injuries in the U.S. military: descriptive epidemiology and recommendations for improvement. *Am J Prev Med*. 2010;38(suppl 1):S42-60.
6. Armed Forces Health Surveillance Center. Absolute and relative morbidity burdens attributable to various illness and injuries, U.S. Armed Forces, 2011. *MSMR*. 2012;19(4):4-9.
7. Armed Forces Health Surveillance Center. Absolute and relative morbidity burden attributable to various illnesses and injuries, U.S. Armed Forces, 2010. *MSMR.* 2011;18(4):2-7.
8. Ruscio BA, Jones BH, Bullock SH et al. A process to identify military injury prevention priorities based on injury type and limited duty days. *Am J Prev Med*. 2010;38(suppl 1):S19-33.
9. U.S. Department of Defense Inspector General. *Evaluation of DoD Accident Reporting.* Arlington, VA: Deputy Inspector General for Special Plans & Operations; 2010. SPO-2010-007.
10. Krahl PL, Jankosky CJ, Thomas RJ, Hooper TI. Systematic review of military motor vehicle crash-related injuries. *Am J Prev Med*. 2010;38(suppl 1):S189-196.
11. Krull AR, Jones BH, Dellinger AM, Yore MM, Amoroso PJ. Motor vehicle fatalities among men in the U.S. Army from 1980 to 1997. *Mil Med.* 2004;169(11):926-931.
12. Writer JV, DeFraites RF, Keep LW. Non-battle injury casualties during the Persian Gulf War and other deployments. *Am J Prev Med*. 2000;18(suppl 3):64-70.
13. United Services Automobile Association. Returning warriors driving safety report 2012. https://content.usaa.com/mcontent/static_assets/Media/Returning_Warriors_report_summary.pdf. Accessed October 14, 2014.
14. Woodall KA, Jacobson IG, Crum-Cianflone NF. Deployment experiences and motor vehicle

crashes among U.S. service members. *Am J Prev Med*. 2014;46(4):350-358.

15. World Health Organization. *Gender and Road Traffic Injuries*. Gender and Health Information Sheet. http://whqlibdoc.who.int/gender/2002/a85576.pdf?ua=1. Retrieved October 14, 2014.

16. Newcomb D. Why it took decades for a female crash test dummy to debut: automakers for years fought to use only crash test dummies modeled after the average American male [editorial]. *Exhaust Notes* [newsletter]. 30 August 2012.

17. Fortuna RJ, Robbins BW, Halterman JS. Ambulatory care among young adults in the United States. *Ann Intern Med.* 2009;151(6):379-385.

18. Armed Forces Health Surveillance Center. Absolute and relative morbidity burdens attributable to various illnesses and injuries, U.S. Armed Forces, 2013. *MSMR.* 2014;21(4):2-7.

19. Defense Safety Oversight Council. *DoD Military Injury Prevention Priorities Working Group: Leading Injuries, Causes, and Mitigation Recommendations*. http://oai.dtic.mil/oai/oai?verb=getRecord%26metadataPrefix=html%26identifier=ADA458257. Accessed October 14, 2014.

20. Fernandes R, Hatfield J, Soames Job RF. A systematic investigation of differential predictors for speeding, drink-driving, driving while fatigued, and not wearing a seat belt among young drivers. *Transportation Research Part F.* 2010;13(3):179-196.

21. Fernandes R, Soames Job RF, Hatfield J. A challenge to the presumed generalizability of prediction and countermeasure for risky driving: different factors predict different risky behaviors. *J Safety Res.* 2007;38(1):59-70.

Appendix

Zip Codes by Location

The table below lists the zip codes used to identify Department of the Navy personnel based in each location of specific interest. Zip codes associated with service members' duty stations were identified using (1) the Defense Manpower Data Center Unit Identification Code address list, (2) Base Facility Identification, and (3) the U.S. Postal Service website.

Location	Zip Codes
San Diego, CA	91932, 92028, 92054, 92055, 92069, 92101–92124, 92126–92140, 92142, 92143, 92145, 92147, 92149, 92150, 92152–92155, 92158–92179, 92182, 92184, 92186–92188, 92190–92193, 92195–92199
Jacksonville, NC	28542, 28545, 28533, 28547
Norfolk, VA	23320, 23322, 23435, 23451, 23452, 23455, 23456, 23459, 23460, 23461, 23464, 23501–23515, 23517–23521, 23523, 23529, 23541, 23551, 23604, 23607, 23651, 23665, 23690, 23691, 23702, 23704, 23708, 23709

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
11/05/2015

2. REPORT TYPE
Technical Report

3. DATES COVERED *(From - To)*
August 2014 - June 2015

4. TITLE AND SUBTITLE
Estimating Rates of Motor Vehicle Crashes Using Medical Encounter Data: A Feasibility Study

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Thomsen, Cynthia J., PhD; Levine, Jordan A., MPH; Altarejos, Isabel V., MPH; Highfill-McRoy, Robyn M., MA, MPH; McAnany, Jennifer, PhD; Ray, Travis N., BA

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
N1427

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Commanding Officer
Naval Health Research Center
140 Sylvester Rd
San Diego, CA 92106-3521

8. PERFORMING ORGANIZATION REPORT NUMBER
Report No. 16-01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Commanding Officer
Naval Medical Research Center
503 Robert Grant Ave
Silver Spring, MD 20910-7500

Chief, Bureau of Medicine and Surgery
(MED 00), Navy Dept
7700 Arlington Blvd Ste 5113
Falls Church, VA 22042-5113

10. SPONSOR/MONITOR'S ACRONYM(S)
BUMED/NMRC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Prepared for the Office of the Deputy Assistant Secretary of the Navy for Safety.

14. ABSTRACT
The present feasibility study was undertaken to determine whether medical encounter data can be used to estimate rates of nonfatal motor vehicle crashes (MVCs) among Sailors and Marines. The study also aimed to describe characteristics of medical encounters for MVC-related injuries and investigate differences in MVC rates over time and as a function of branch of service, gender, rank, deployment history, and location. A comprehensive database for the 5-year period from 2009 to 2013 was constructed by merging three separate databases containing accession and demographic data, inpatient and outpatient medical care, and deployments in support of the Global War on Terror.

15. SUBJECT TERMS
motor vehicle crashes, safety, risk reduction

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Commanding Officer
					19b. TELEPHONE NUMBER *(Include area code)*
UNCL	UNCL	UNCL	UNCL	35	COMM/DSN: (619) 553-8429